

(12) **United States Patent**
Mitsumata et al.

(10) **Patent No.:** **US 10,359,718 B2**
(45) **Date of Patent:** **Jul. 23, 2019**

(54) **IMAGE FORMING APPARATUS**

15/1089; G03G 15/0194; G03G 15/1605;
G03G 15/1615; G03G 15/162; G03G
15/165; G03G 15/1685; G03G 2215/16;
G03G 2215/1642

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USPC 399/313
See application file for complete search history.

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **15/887,704**

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(22) Filed: **Feb. 2, 2018**

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(65) **Prior Publication Data**

US 2018/0157197 A1 Jun. 7, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/163,136, filed on
May 24, 2016, now Pat. No. 9,921,525.

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Primary Examiner — Rodney E Fuller

(30) **Foreign Application Priority Data**

May 28, 2015 (JP) 2015-109182

(74) *Attorney, Agent, or Firm* — Canon U.S.A. Inc., IP
Division

(51) **Int. Cl.**
G03G 15/16 (2006.01)

(57) **ABSTRACT**

A transfer device includes a rubbing member provided in
contact with a transfer belt, a supporting member supporting
the rubbing member, and a damping member configured to
damp vibration of the transfer device. The damping member
is fastened to the supporting member, and an end of the
damping member in a width direction that is orthogonal to
a direction of rotation of the transfer belt is a free end.

(52) **U.S. Cl.**
CPC **G03G 15/1615** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0163; G03G 15/0131; G03G

28 Claims, 18 Drawing Sheets

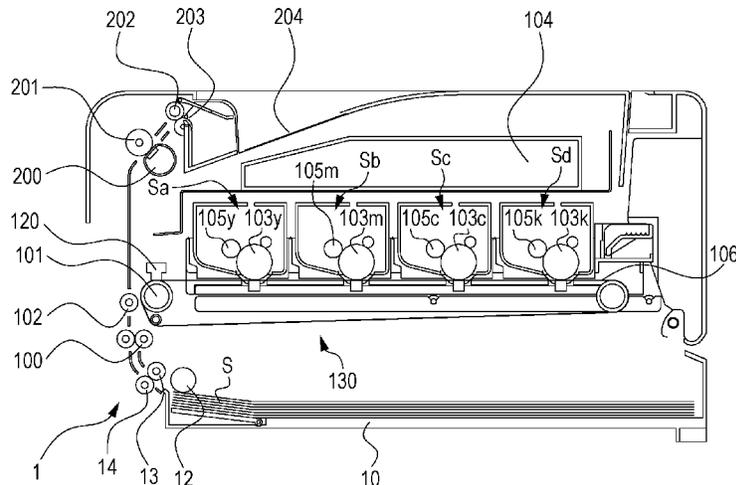


FIG. 1

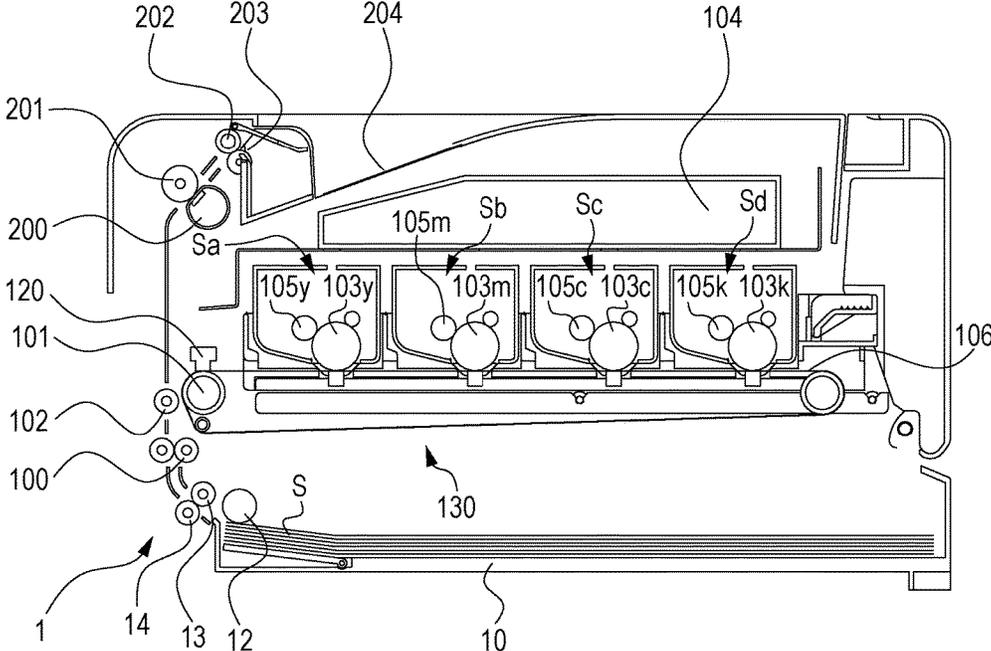


FIG. 2

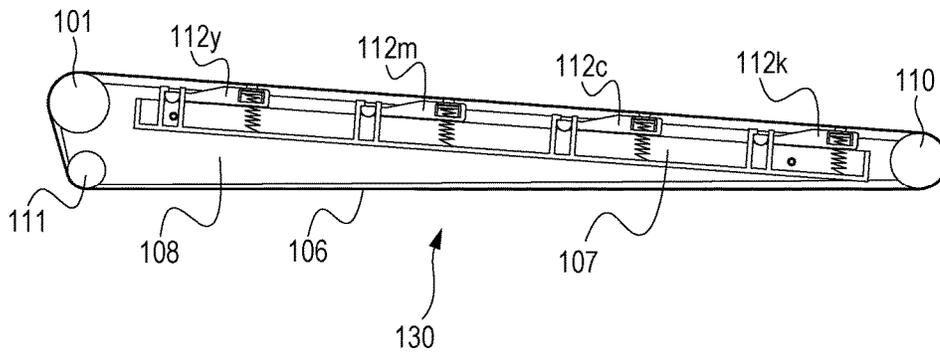


FIG. 3

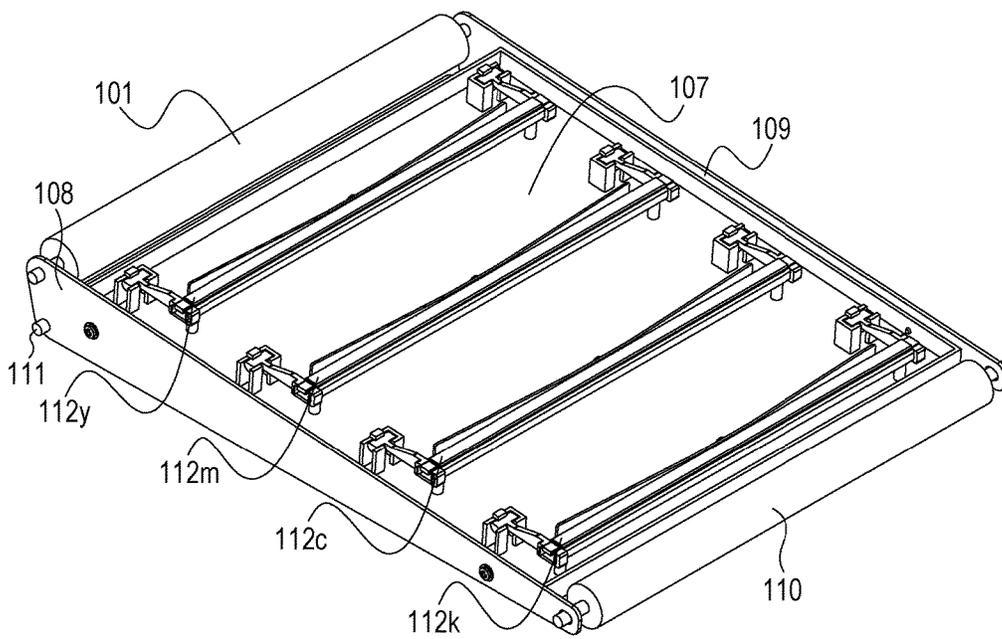


FIG. 4

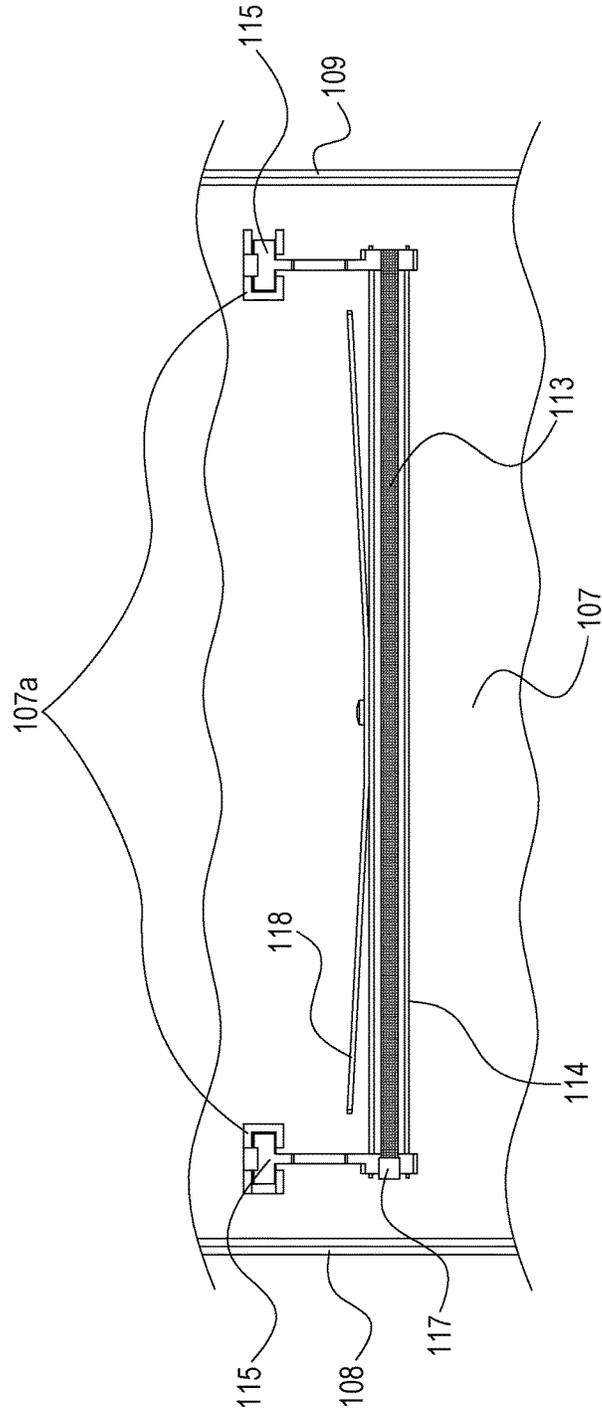


FIG. 5

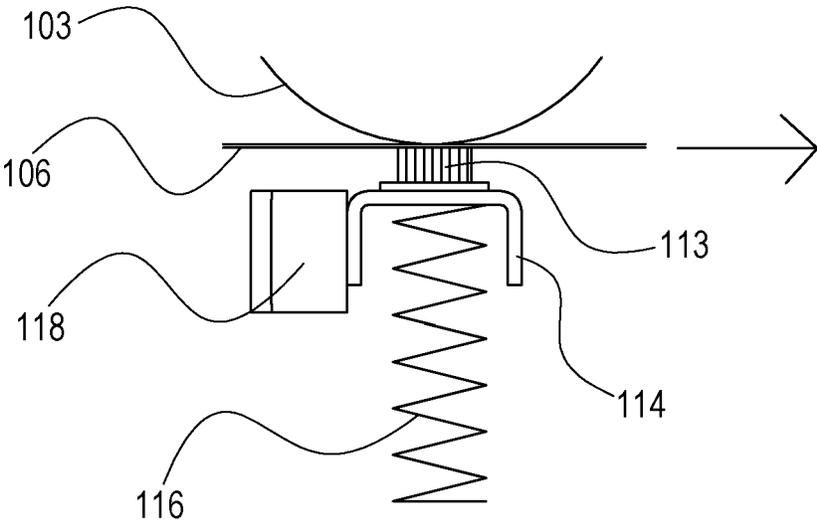


FIG. 6A

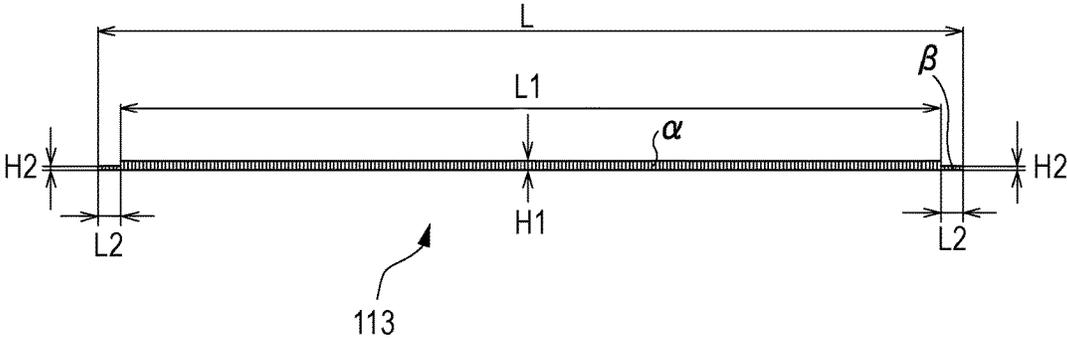


FIG. 6B

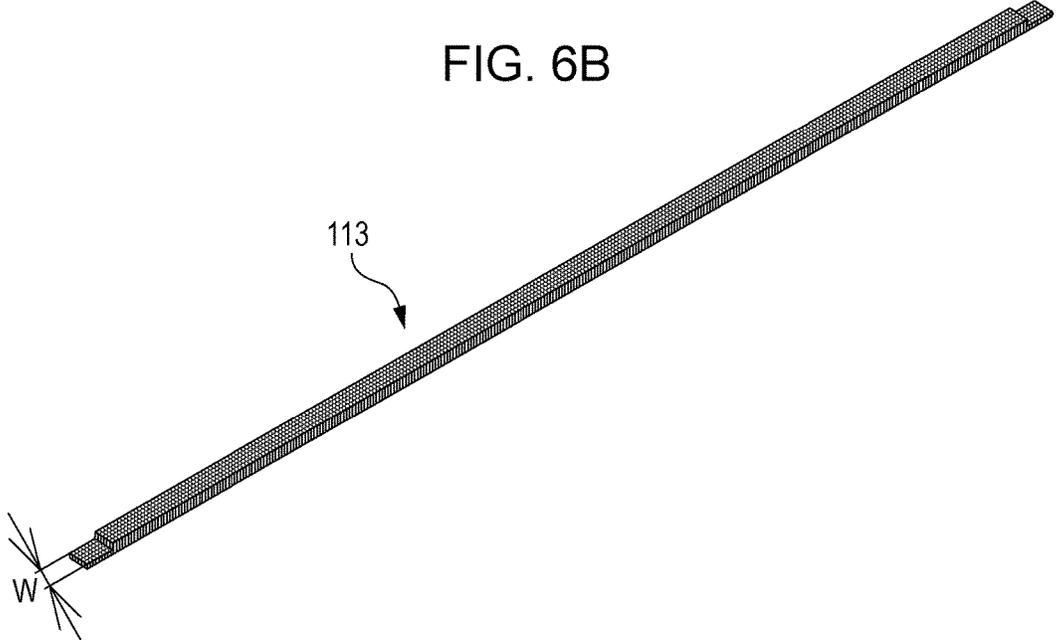


FIG. 7

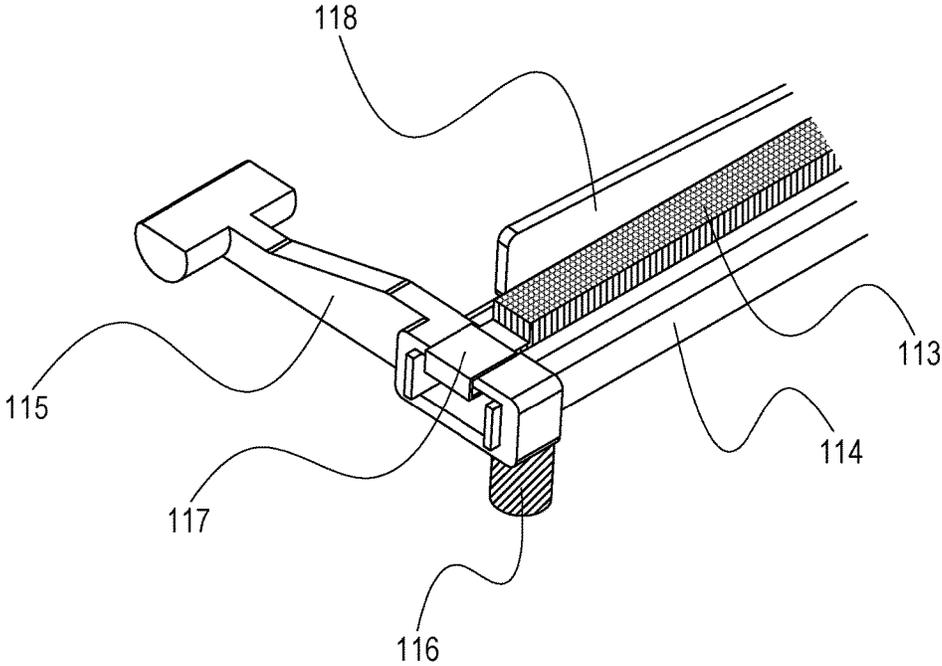


FIG. 8

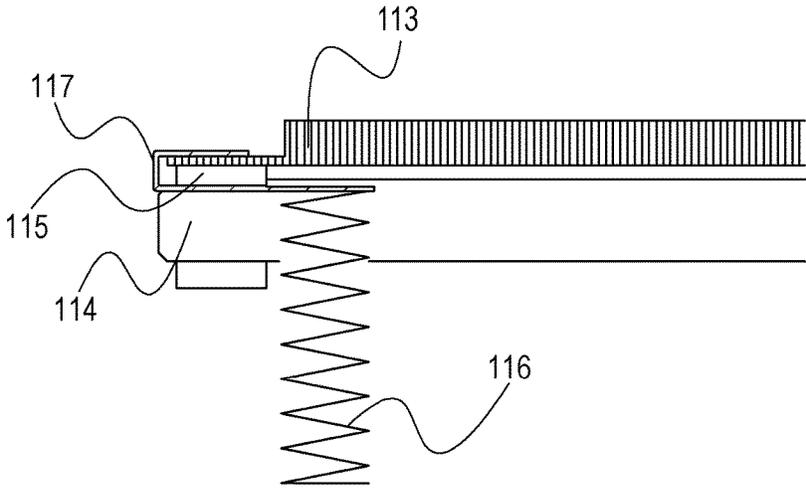


FIG. 9

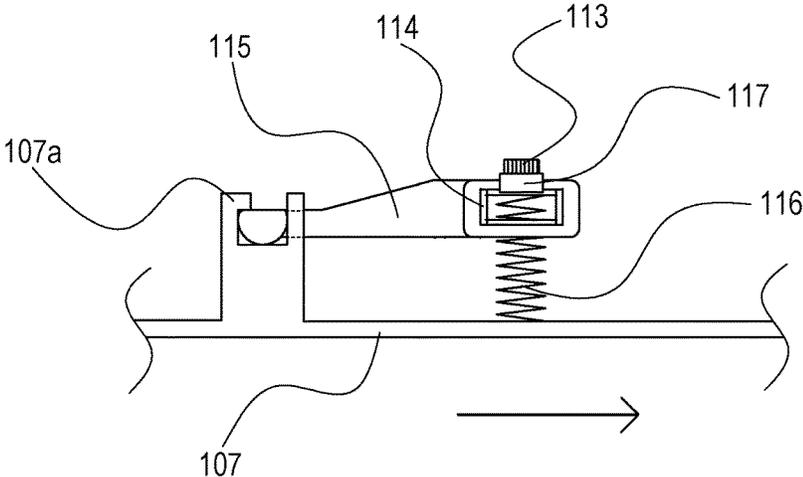


FIG. 10

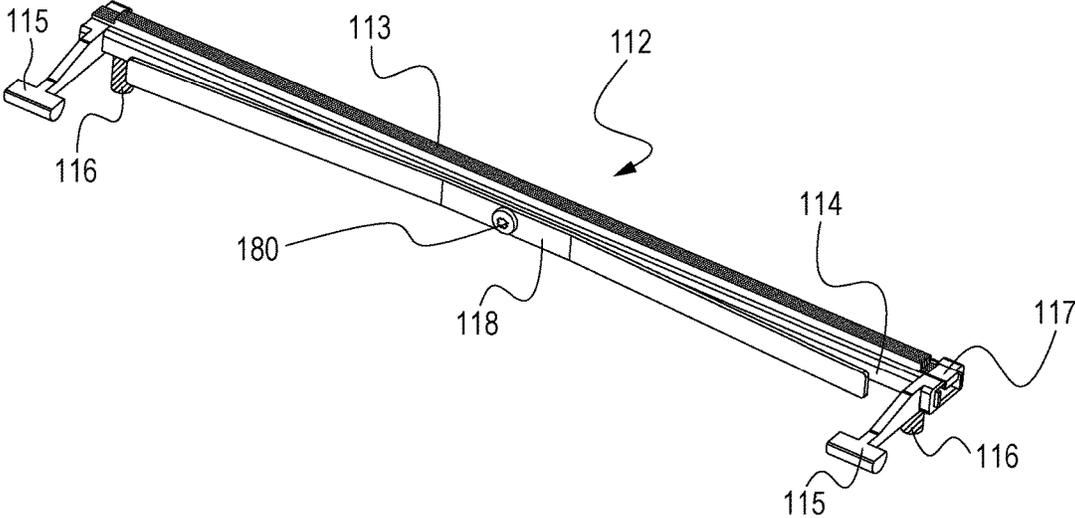


FIG. 11A

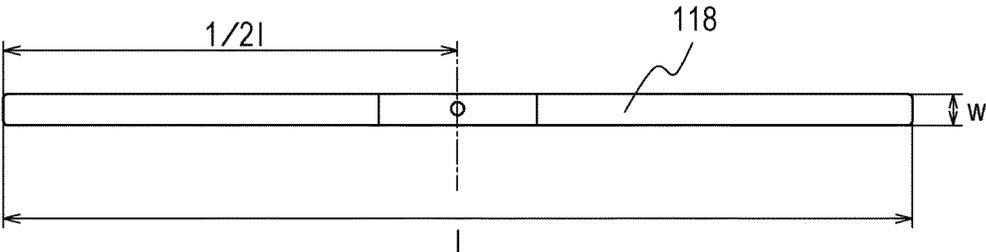


FIG. 11B

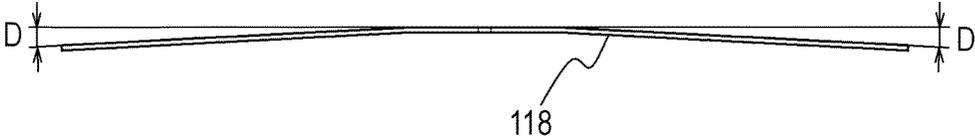


FIG. 12

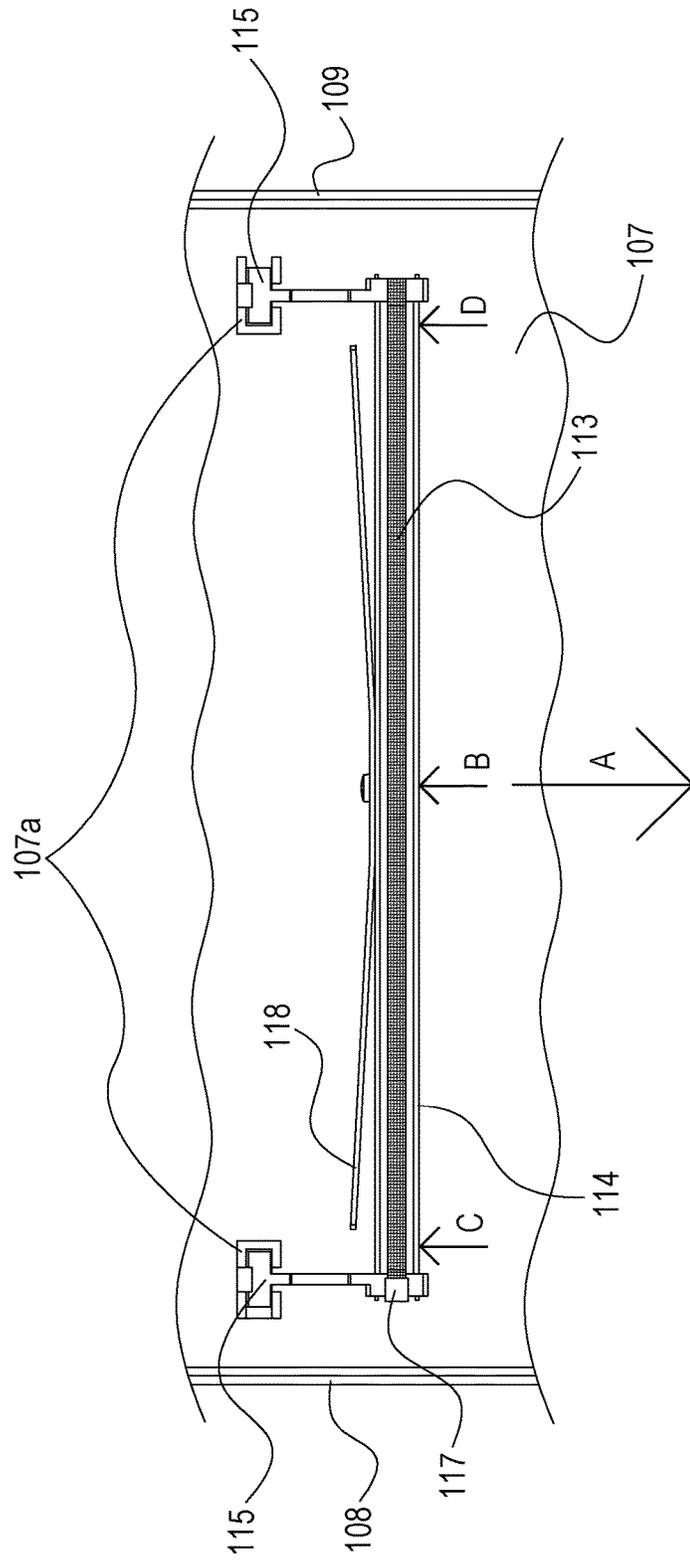


FIG. 13A

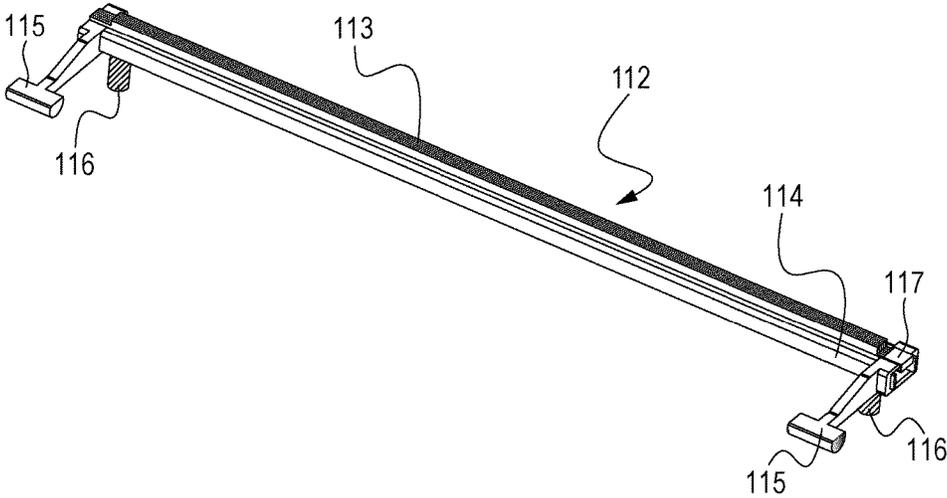


FIG. 13B

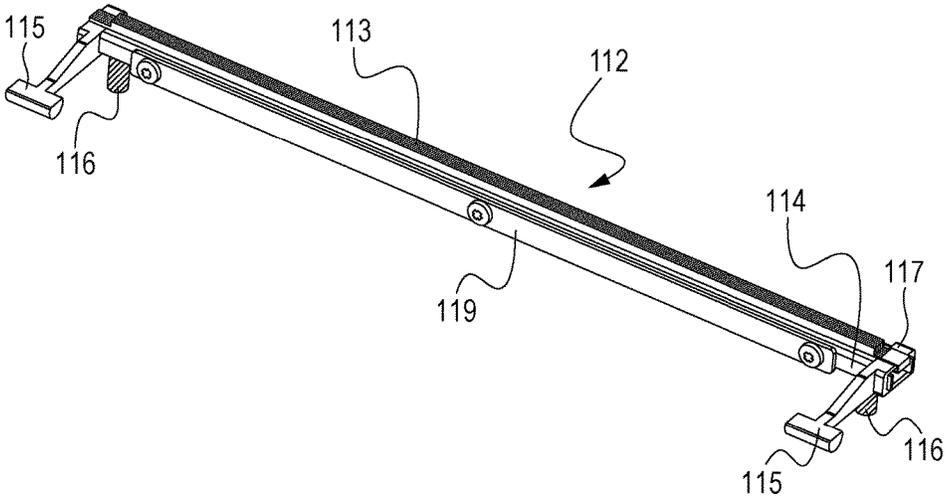


FIG. 14

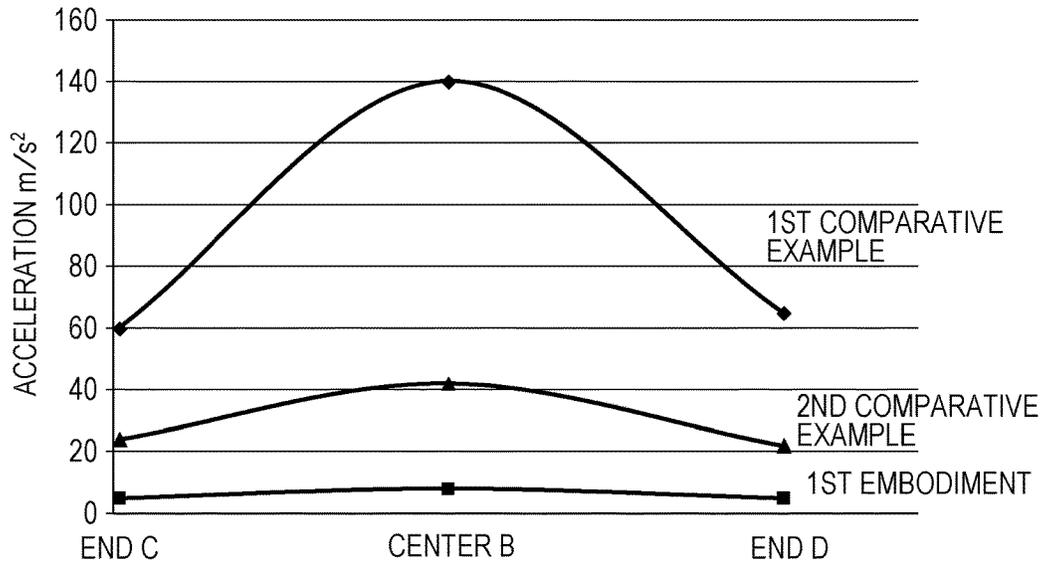


FIG. 15

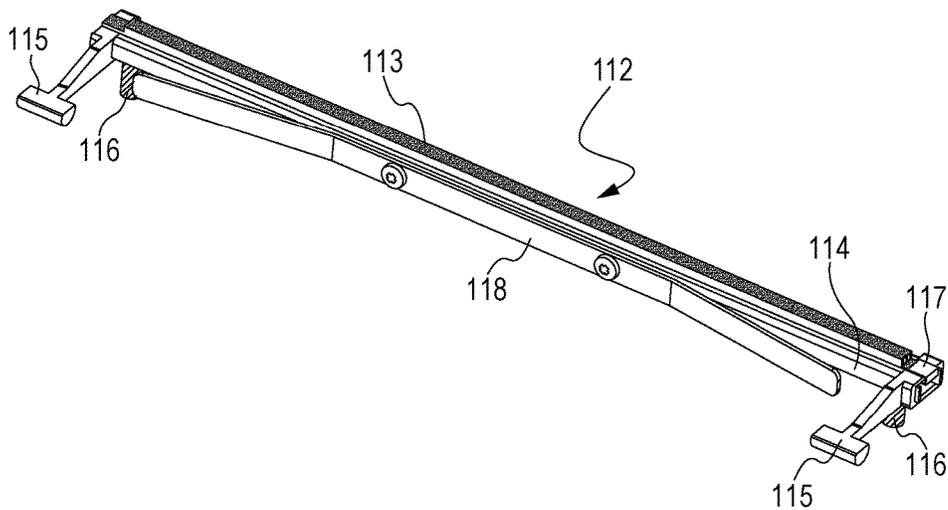


FIG. 16

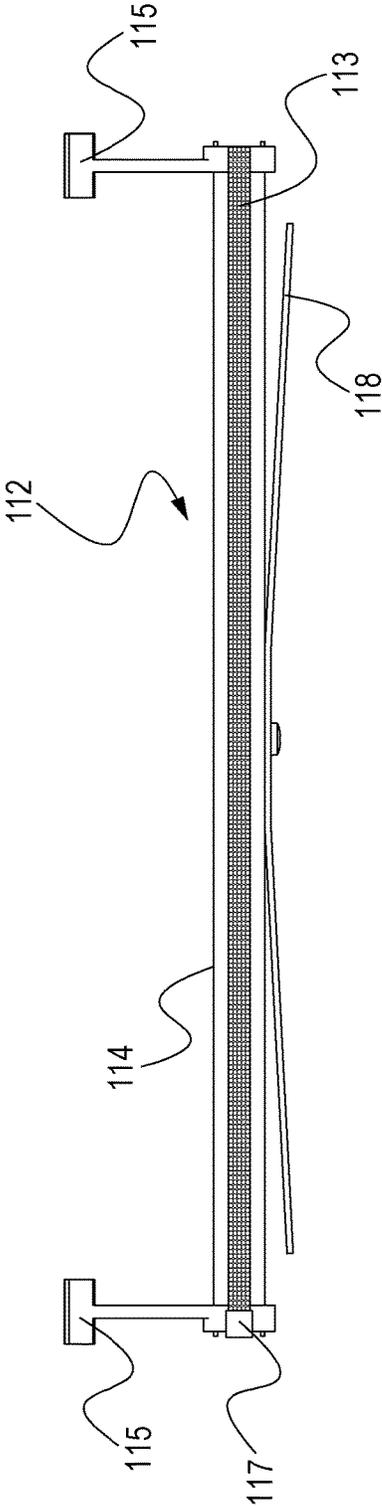


FIG. 17A

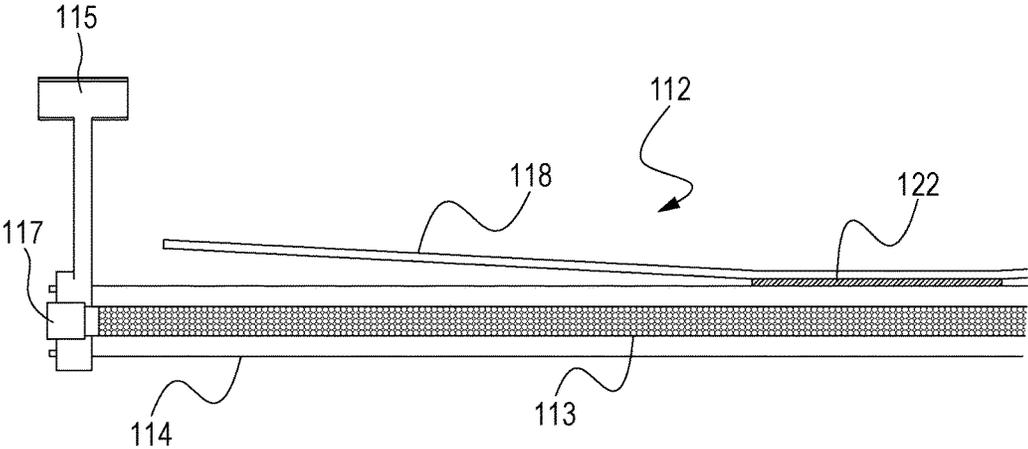


FIG. 17B

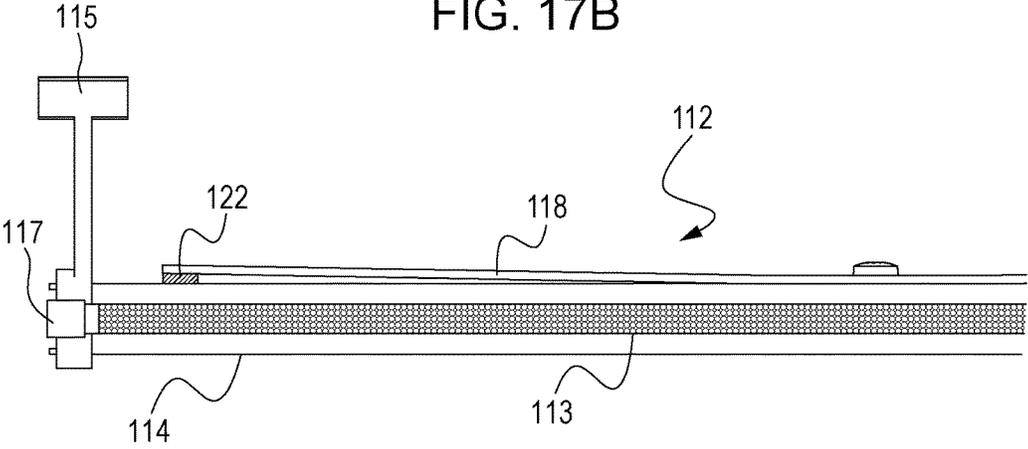


FIG. 18A

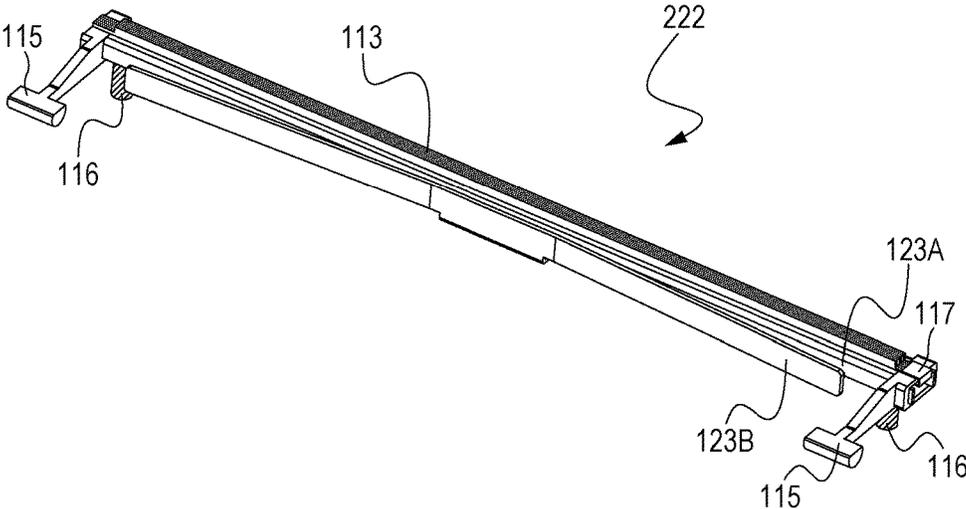


FIG. 18B

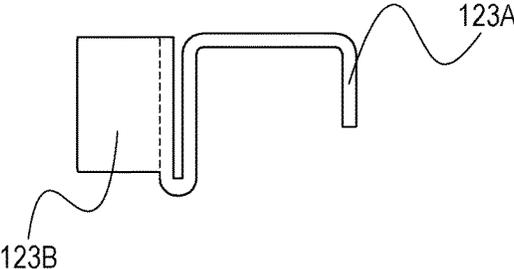


FIG. 19A

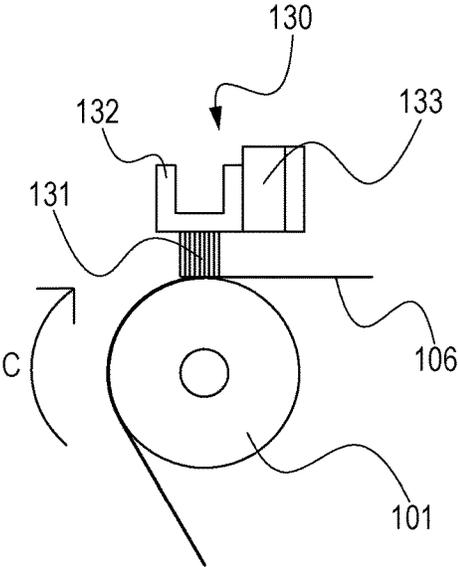


FIG. 19B

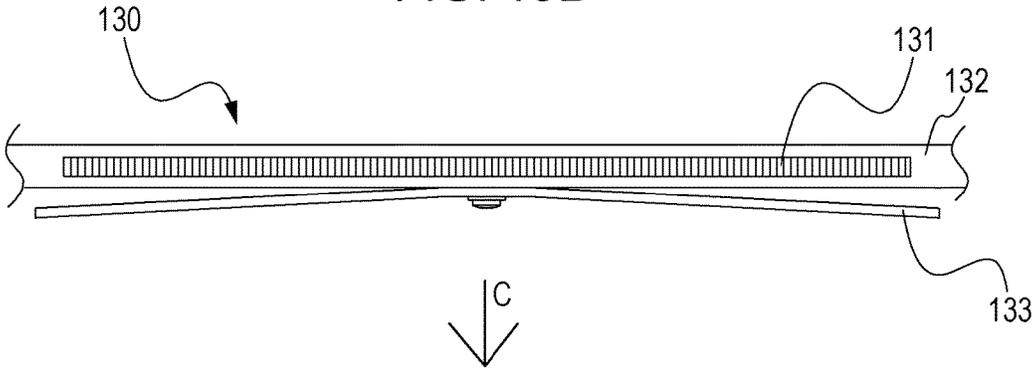


FIG. 20

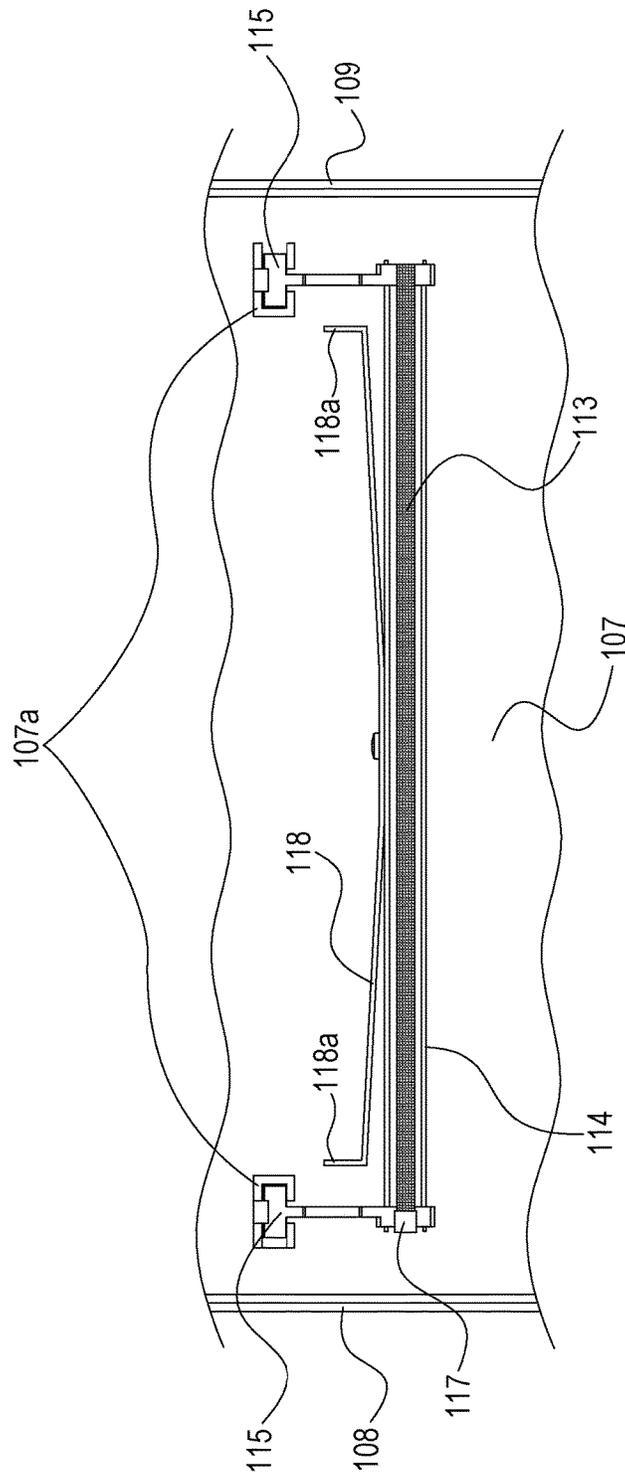


FIG. 21

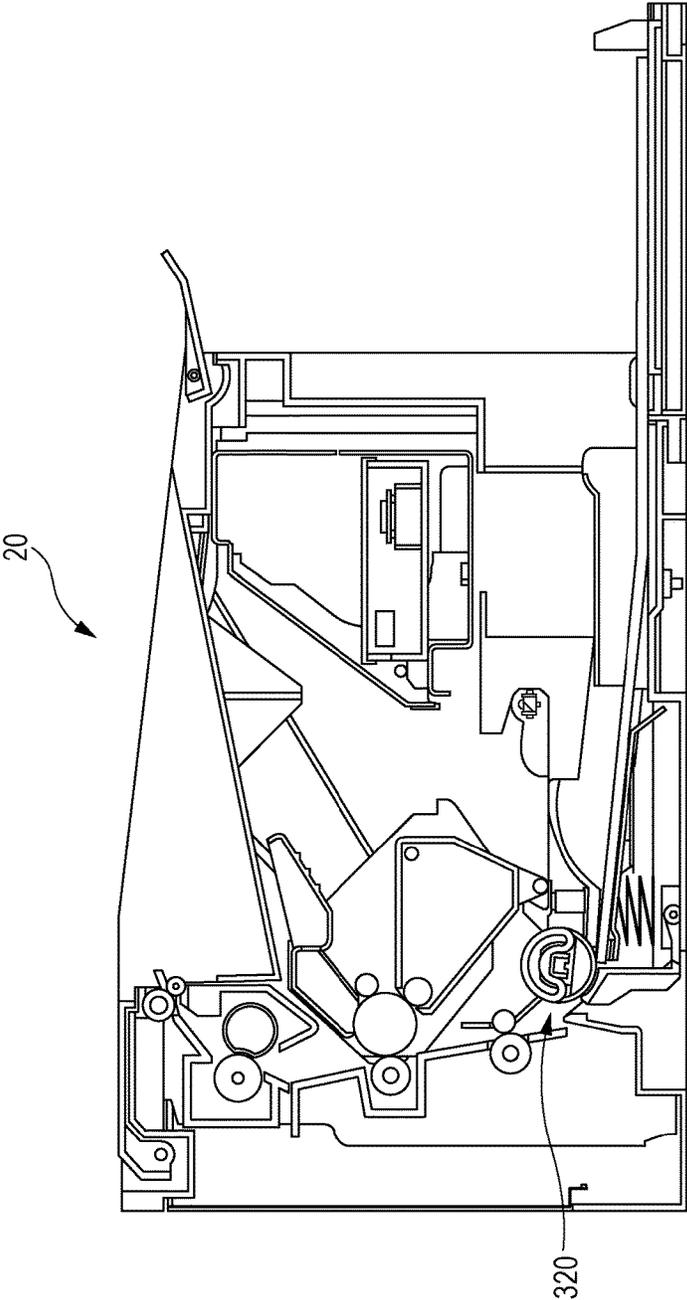


FIG. 22

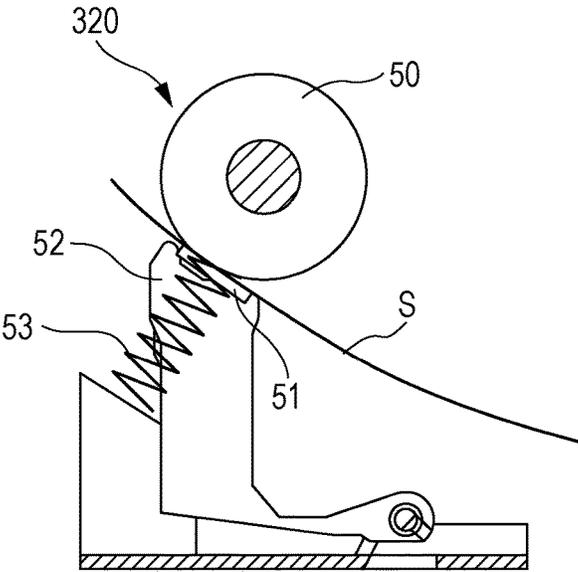


FIG. 23

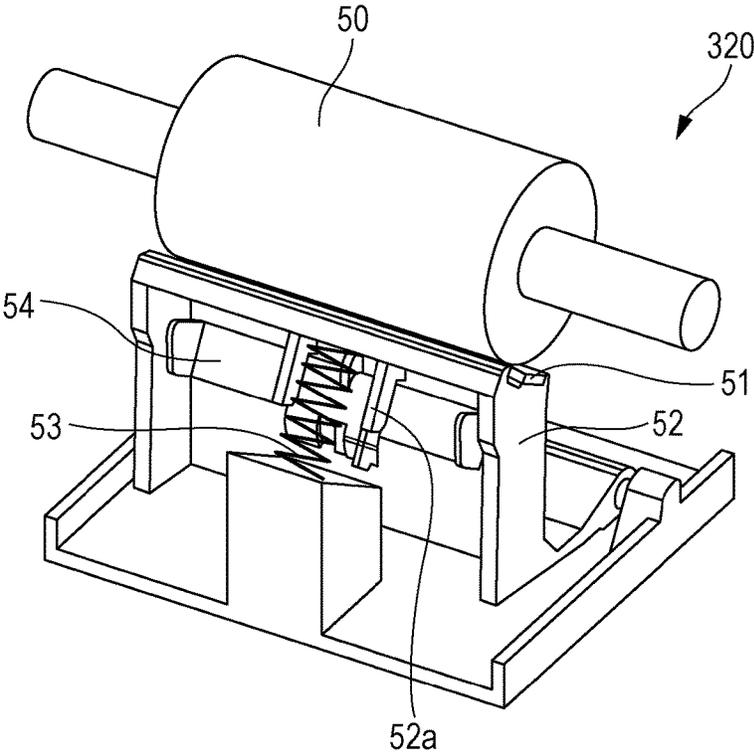


IMAGE FORMING APPARATUS

This application is a continuation, and claims the benefit, of U.S. patent application Ser. No. 15/163,136, presently pending and filed on May 24, 2016, and claims the benefit of, and priority to, Japanese Patent Application No. 2015-109182, filed May 28, 2015, which applications are hereby incorporated by reference herein in their entireties.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image forming apparatus, such as a copier, a printer, a facsimile, or a multifunction machine, configured to form an image on a sheet.

Description of the Related Art

Some related-art electrophotographic image forming apparatuses, such as a copier or a printer, employ intermediate transfer belts as transfer belts. In such an image forming apparatus employing an intermediate transfer belt, a full-color image is formed through a primary-transfer step and a secondary-transfer step.

In the primary-transfer step, a toner image formed on a surface of an electrophotographic photoconductive member is primarily transferred to the intermediate transfer belt. The primary-transfer step is performed for forming each of a plurality of toner images in different colors, whereby a combination of toner images in different colors is formed on the intermediate transfer belt. In the secondary-transfer step, the combination of toner images in different colors is transferred to a surface of a transfer material such as a piece of paper. The combination of toner images thus transferred to the transfer material is then fixed by a fixing device. Thus, a full-color image is obtained.

A transfer device included in such an image forming apparatus includes a transfer member in the form of a roller, a blade, a brush, or the like. The transfer member is a contact member that is provided in contact with the inner peripheral surface of the intermediate transfer belt at a position across from the photoconductive member.

In Japanese Patent Laid-Open No. 2011-248385, an image forming apparatus including a brush-type transfer member as a transfer device is disclosed. The brush-type transfer member according to Japanese Patent Laid-Open No. 2011-248385 includes a stainless-steel metal holder (a supporting member) that supports a brush thereon with the aid of two-sided adhesive tape. The brush include a plurality of conductive fibers. That is, the transfer member according to Japanese Patent Laid-Open No. 2011-248385 is disclosed as a brush-type rubbing member that is unrotatably in contact with the intermediate transfer belt and thus rubs the intermediate transfer belt.

Employing such a rubbing member as in Japanese Patent Laid-Open No. 2011-248385 generates a large frictional force between the rubbing member and the intermediate transfer belt and may lead to, for example, bending of the rubbing member or the supporting member or generation of noise due to vibration of the rubbing member or the supporting member caused by a stick-slip phenomenon or the like. Such a condition occurs not only in the case of the intermediate transfer belt but also in a case of a conveying belt that bears and conveys the transfer material and in a case

of any other rubbing member that may vibrate by rubbing a moving object provided in the image forming apparatus.

SUMMARY OF THE INVENTION

The present invention provides a simple mechanism that damps the vibration of a supporting member due to a frictional force generated between a rubbing member and a rubbed member.

According to an aspect of the present invention, there is provided an image forming apparatus including an image bearing member configured to bear a toner image, a rotatable transfer belt to which the toner image on the image bearing member is transferred to a transfer material, and a transfer device provided in contact with the transfer belt and configured to transfer the toner image from the image bearing member to the transfer belt. The transfer device includes a rubbing member provided in contact with the transfer belt, a supporting member supporting the rubbing member, and a damping member configured to damp vibration of the transfer device. The damping member is fastened to the supporting member, and an end of the damping member in a width direction that is orthogonal to a direction of rotation of the transfer belt is a free end.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sectional view of an image forming apparatus according to a first embodiment of the present invention.

FIG. 2 is a schematic sectional view of an intermediate transfer unit according to the first embodiment.

FIG. 3 is a schematic perspective view of the intermediate transfer unit.

FIG. 4 is a schematic top view of a primary-transfer unit according to the first embodiment.

FIG. 5 is a schematic diagram illustrating the relationship between the primary-transfer unit and a photoconductive drum according to the first embodiment.

FIG. 6A is a diagram illustrating dimensions of a transfer member in a belt-width direction according to the first embodiment.

FIG. 6B is a schematic perspective view of the transfer member.

FIG. 7 is a perspective view of one end of the primary-transfer unit according to the first embodiment.

FIG. 8 is a sectional view of the one end of the primary-transfer unit according to the first embodiment.

FIG. 9 is a schematic sectional view of the primary-transfer unit that is seen in the axial direction thereof according to the first embodiment.

FIG. 10 is a perspective view of the primary-transfer unit that is seen from the downstream side in a direction of belt rotation according to the first embodiment.

FIG. 11A is a side view of a damping member according to the first embodiment and illustrates dimensions thereof.

FIG. 11B is a diagram illustrating the angle of the damping member.

FIG. 12 is another schematic top view of the primary-transfer unit according to the first embodiment.

FIG. 13A is a perspective view of a primary-transfer unit according to a first comparative example.

FIG. 13B is a perspective view of a primary-transfer unit according to a second comparative example.

FIG. 14 is a graph given for comparison of acceleration among the first embodiment, the first comparative example, and the second comparative example.

FIG. 15 is a schematic diagram of a primary-transfer unit according to a first modification of the first embodiment.

FIG. 16 is a schematic diagram of a primary-transfer unit according to a second modification of the first embodiment.

FIGS. 17A and 17B are schematic diagrams of primary-transfer units according to third and fourth modifications, respectively, of the first embodiment.

FIGS. 18A and 18B are schematic diagrams of a primary-transfer unit according to a fifth modification of the first embodiment.

FIGS. 19A and 19B are schematic diagrams of a charging unit according to a second embodiment of the present invention.

FIG. 20 is a schematic diagram of a primary-transfer unit according to a sixth modification of the first embodiment.

FIG. 21 is a schematic diagram of a sheet feeding mechanism according to a third embodiment of the present invention.

FIG. 22 is a sectional view of the sheet feeding mechanism.

FIG. 23 is a perspective view of the sheet feeding mechanism.

DESCRIPTION OF THE EMBODIMENTS

Referring to the attached drawings, embodiments of the present invention will now be described in detail. Dimensions, materials, shapes, relative arrangements, and other factors of elements described herein should be changed appropriately in accordance with the configuration and associated conditions of an apparatus to which the present invention is applied. Hence, the following embodiments do not limit the scope of the present invention thereto unless otherwise specified.

First Embodiment

FIG. 1 is a schematic sectional view of an image forming apparatus 1 according to a first embodiment of the present invention. The image forming apparatus 1 according to the first embodiment is an electrophotographic full-color laser-beam printer. The image forming apparatus 1 electrophotographically forms an image on a transfer material, such as a recording sheet or an overhead-projector (OHP) sheet, in accordance with a signal transmitted to the image forming apparatus 1 from an external apparatus, such as a personal computer, communicably connected to the image forming apparatus 1.

In the image forming apparatus 1 according to the first embodiment illustrated in FIG. 1, surfaces of photoconductive drums (image bearing members) 103y, 103m, 103c, and 103k are charged by charging rollers 105y, 105m, 105c, and 105k, respectively. The charged surfaces of the photoconductive drums 103y, 103m, 103c, and 103k are exposed to light emitted from a laser scanner 104, serving as an exposure device, in accordance with image information, whereby electrostatic latent images are formed on the respective photoconductive drums 103y, 103m, 103c, and 103k. The electrostatic latent images are developed with yellow, magenta, cyan, and black toners by developing members 112y, 112m, 112c, and 112k, respectively, whereby toner images in the respective colors are formed. The toner images thus formed on the respective photoconductive drums 103y, 103m, 103c, and 103k are primarily transferred

to an intermediate transfer belt 106, which is in the form of an endless transfer belt, in such a manner as to be superposed one on top of another.

Meanwhile, one of transfer materials S stacked in a cassette 10 is conveyed by a feed roller 12, a conveying roller 13, a separating roller 14, and a pair of registration rollers 100 to a nip (secondary-transfer part) defined between a secondary-transfer counter roller 101 and a secondary-transfer roller 102.

The transfer material S thus conveyed to the secondary-transfer part undergoes the secondary transfer, in which the toner images superposed on the intermediate transfer belt 106 are secondarily transferred to the transfer material S. The transfer material S now having the toner images is heated and pressed by a fixing device (including a fixing film 200 and a pressing roller 201), whereby the toner images on the transfer material S are fixed. The transfer material S now having the fixed toner images is discharged onto a discharge tray 204 by a discharge roller 202 and a discharge follower roller 203.

Residual toner particles on the surface of the intermediate transfer belt 106 that has undergone the secondary transfer are charged by a residual-toner-charging unit 120. In this step, the residual toner particles are charged by the residual-toner-charging unit 120 to a polarity opposite to the normal polarity and are then moved from the intermediate transfer belt 106 to the photoconductive drums 103y, 103m, 103c, and 103k at respective primary-transfer parts.

To form a full-color image, the above steps of charging, exposure, development, and primary transfer are performed in first to fourth stations Sa, Sb, Sc, and Sd in that order from the upstream side in a direction of rotation of the intermediate transfer belt 106. Thus, a full-color image that is composed of toner images having the four colors of yellow, magenta, cyan, and black and superposed one on top of another on the intermediate transfer belt 106 is formed on the transfer material S. To form a monochrome (mono-color) image, the steps of charging, exposure, development, and primary transfer are performed in any one of the first to fourth stations Sa, Sb, Sc, and Sd.

Now, a configuration of an intermediate transfer unit 130 as a transfer unit will be described. FIG. 2 is a schematic sectional view of the intermediate transfer unit 130. FIG. 3 is a schematic perspective view of the intermediate transfer unit 130. The intermediate transfer unit 130 according to the first embodiment illustrated in FIGS. 2 and 3 is attachable to and detachable from the body of the image forming apparatus 1.

In the intermediate transfer unit 130, the intermediate transfer belt 106 having an endless shape and being rotatable is stretched around three stretching rollers: namely, the secondary-transfer counter roller 101, a tension roller 110, and an assist roller 111. The secondary-transfer counter roller 101, the tension roller 110, and the assist roller 111 are each rotatably supported by a left side plate 108 and a right side plate 109. The primary-transfer units 112y, 112m, 112c, and 112k are supported by a unit frame 107 at respective positions facing the respective photoconductive drums 103y, 103m, 103c, and 103k.

The tension roller 110 urges the intermediate transfer belt 106 from the inner side of the intermediate transfer belt 106 with a tension spring (not illustrated) and thus defines, with the aid of the assist roller 111, a belt surface along which the transfer material S is guided to the secondary-transfer part.

Now, a configuration of each of the primary-transfer units 112y, 112m, 112c, and 112k, as transfer devices, according to the first embodiment will be described. The primary-

transfer units **112_y**, **112_m**, **112_c**, and **112_k** are provided for the respective colors and all have the same configuration. Therefore, the suffixes y, m, c, and k in the reference numerals given to associated elements are omitted in the following description. The primary-transfer units **112** are each a transfer device that transfers a toner image from a corresponding one of the photoconductive drums **103** to the intermediate transfer belt **106** (the transfer belt). FIG. 4 is a schematic top view of the primary-transfer unit **112**. FIG. 5 is a schematic diagram illustrating the relationship between the primary-transfer unit **112** and the photoconductive drum **103**.

As illustrated in FIGS. 4 and 5, the primary-transfer unit **112** includes a transfer member **113** that is in contact with the inner peripheral surface of the intermediate transfer belt **106**, and a supporting member **114** that supports the transfer member **113**. The transfer member **113** is fixed to the supporting member **114** in such a manner as to be unrotatable with respect to the intermediate transfer belt **106**, which is rotatable. The transfer member **113** in such a state is in contact with the intermediate transfer belt **106**. Therefore, the transfer member **113** rubs the intermediate transfer belt **106**. The primary-transfer unit **112** further includes positioning portions **115**, pressing members **116** as compression springs, a contact member **117** as a power feeding unit, and a damping member **118**. The positioning portions **115** determine the position of the transfer member **113** with respect to the photoconductive drum **103** in the direction of rotation of the intermediate transfer belt **106**.

The transfer member **113** is pressed toward the photoconductive drum **103** by the pressing members **116**. Hence, the photoconductive drum **103** and the intermediate transfer belt **106** are closely in contact with each other, and the intermediate transfer belt **106** and the transfer member **113** are closely in contact with each other.

Referring to FIG. 6A, a length L of the transfer member **113** in the long-side direction thereof (a widthwise direction of the intermediate transfer belt **106** that is orthogonal to the direction of rotation of the intermediate transfer belt **106**) is 238 mm. Referring to FIG. 6B, a width W of the transfer member **113** in the short-side direction thereof (corresponding to the direction of rotation of the intermediate transfer belt **106**) is 4 mm. The transfer member **113** is a brush member that includes a base fabric portion (not illustrated) and a nap portion α . The nap portion α includes a plurality of conductive fibers (for example, conductive nylon fibers) and is fixed to the base fabric portion. The base fabric portion is supported by the supporting member **114**. The transfer member **113** is sectioned in the long-side direction thereof, i.e., in the widthwise direction of the intermediate transfer belt **106**, into the nap portion α and two welded end parts β .

The nap portion α of the transfer member **113** has a length L1 of 216 mm, and the welded end parts β of the transfer member **113** at the two ends of the nap portion α each have a length L2 of 11 mm.

The nap portion α has a thickness H1 of about 1.5 mm, and the welded end parts β each have a thickness H2 of about 0.5 mm. The nap portion α has elasticity and is in contact with the intermediate transfer belt **106**. The transfer member **113** may be made of any of the following materials: conductive urethane foam, an ultrahigh-molecular-weight polyethylene transfer material, and the like; and any combination of the foregoing materials.

The transfer member **113** is fixedly attached to the top surface of the supporting member **114** with two-sided adhesive tape (not illustrated) and is thus supported by the

supporting member **114**. The supporting member **114** is made of a steel plate having a thickness of 0.8 mm and has a rectangular U shape in cross-sectional view. FIG. 7 is a perspective view of one end of the primary-transfer unit **112**. FIG. 8 is a sectional view of the one end of the primary-transfer unit **112**.

The contact member **117** is a leaf-spring-type member having a rectangular U shape. The positioning portions **115** are each connected to a corresponding one of the two ends of the supporting member **114**. The contact member **117** pinches the welded end part β (a part of the transfer member **113**) and the positioning portion **115** at the one end of the primary-transfer unit **112**. The upper inner surface of the contact member **117** is in contact with the welded end part β of the transfer member **113**. The lower outer surface of the contact member **117** is in contact with the pressing member **116** at the one end of the primary-transfer unit **112**. The transfer member **113** is pressed by the pressing member **116** with the positioning portion **115** and the supporting member **114** interposed therebetween. The pressing member **116** is a conductive compression spring. The other end of the primary-transfer unit **112** has the same configuration, except the contact member **117**, which is provided only at the one end of the primary-transfer unit **112**.

Hence, each of the pressing members **116** is electrically connected to the transfer member **113**, and a primary-transfer voltage is allowed to be applied from an electrical board (not illustrated) provided on the body of the image forming apparatus **1** to the transfer member **113** through the pressing members **116** and the contact member **117**. The supporting member **114** and each of the positioning portions **115** are fixed to each other by light press-fitting. The positioning portions **115** are made of resin and are provided at the two respective ends of the supporting member **114** in the widthwise direction of the intermediate transfer belt **106** (the direction is hereinafter referred to as "the belt-width direction").

FIG. 9 is a schematic sectional view of the primary-transfer unit **112** that is seen in the axial direction thereof. As illustrated in FIG. 9, the positioning portions **115** are each in engagement with a supporting portion **107_a** of the unit frame **107**, thereby being positioned in the direction of rotation of the intermediate transfer belt **106** (the direction of the arrow illustrated in FIG. 9, the direction is hereinafter referred to as "the direction of belt rotation"). The positioning portion **115** is rotatable about the point of engagement.

FIG. 10 is a perspective view of the primary-transfer unit **112** that is seen from the downstream side in the direction of belt rotation. As illustrated in FIG. 10, the primary-transfer unit **112** includes the damping member **118**. The damping member **118** is supported by the supporting member **114**. The damping member **118** is made of a steel plate having a thickness of 1.2 mm. The damping member **118** is fastened to a central part, in the belt-width direction, of a side face of the supporting member **114** with a screw **180**, thereby being connected to the supporting member **114**. It is effective to fasten the damping member **118** to the supporting member **114** at a position where the amount of bend that occurs in the supporting member **114** in the direction of belt rotation is largest (details will be described later). Therefore, the damping member **118** according to the first embodiment is fastened to the above position.

FIG. 11A is a side view of the damping member **118** and illustrates the dimensions thereof. FIG. 11B is a diagram illustrating the angle of the damping member **118**. The damping member **118** has a length l of 210 mm in the belt-width direction and has a hole for connection to the

supporting member 114 at the center thereof in the belt-width direction. The damping member 118 has a length w of 9 mm in the direction of belt rotation. The two ends of the damping member 118 in the belt-width direction are free ends and are each shifted by an angle D of 3° with respect to the belt-width-direction center of the damping member 118. That is, the damping member 118 has a curved shape that is bent at the belt-width-direction center thereof by a predetermined angle. Hence, the damping member 118 is out of contact with any members including the supporting member 114, except at the center thereof.

Now, vibration that occurs in the primary-transfer unit 112 will be described. FIG. 12 is a schematic top view of the primary-transfer unit 112 illustrated for explaining the mechanism of vibration that occurs therein. When the intermediate transfer belt 106 starts to rotate, a frictional force and an electrostatic attractive force that is generated by the application of the transfer voltage to the transfer member 113 act between the transfer member 113 and the intermediate transfer belt 106. The frictional force and the electrostatic attractive force cause the transfer member 113 and the supporting member 114 to bend in a bow-like shape that is convex in the direction of belt rotation (the direction of the arrow A in FIG. 12), with the positioning portions 115 at the two ends serving as fixed ends.

In this state, the supporting member 114 exerts a restoring force with its own stiffness. Then, the moment the restoring force exceeds the resultant of the frictional force and the attractive force, a slip occurs between the transfer member 113 and the intermediate transfer belt 106. Consequently, the supporting member 114 returns to its initial position. With repetitions of the above motion, the supporting member 114 vibrates by being repeatedly bent in a bow-like shape, and the vibration generates noise.

To avoid such a situation, the first embodiment features the damping member 118 attached to the primary-transfer unit 112. When the primary-transfer unit 112 vibrates by being repeatedly bent in a bow-like shape, the vibration is transmitted from the supporting member 114 to the damping member 118. Then, the two free ends of the damping member 118 vibrate and consume some kinetic energy. Consequently, the amplitude of vibration of the supporting member 114 is suppressed to be small, and damage to associated members and noise generation caused by the vibration are suppressed more than in the related-art apparatus. Note that there is a delay in the vibration of the damping member 118 with respect to the vibration of the supporting member 114, and the damping member 118 therefore vibrates with a phase different from that of the supporting member 114.

To demonstrate the above advantageous effect produced by the first embodiment, some comparative examples will now be described. FIG. 13A is a perspective view of a primary-transfer unit 112 according to a first comparative example in which no damping member is provided. FIG. 13B is a perspective view of a primary-transfer unit 112 according to a second comparative example in which the damping member 118 is replaced with a reinforcing member 119. The reinforcing member 119 is fastened to the supporting member 114 at three points (the center and the two ends) in the belt-width direction with screws.

An experiment was conducted in which values of the acceleration of the supporting member 114 in the direction of belt rotation when the intermediate transfer belt 106 was rotated while the transfer voltage was applied to the transfer member 113 were compared among the three primary-transfer units 112. The acceleration was measured at the

three points of the supporting member 114 in total in the belt-width direction: specifically, as indicated in FIG. 12, a point B at the center and points C and D at the two ends, with an ultra-compact single-axial accelerometer NP-2016 of ONO SOKKI CO., LTD.

FIG. 14 is a graph illustrating the results of the experiment. The vertical axis represents the acceleration in the direction of belt rotation. The horizontal axis represents the position of the supporting member 114 in the belt-width direction. In the first embodiment, the acceleration was 5 m/s^2 at each of the two ends C and D and 8 m/s^2 at the center B. In the first comparative example, the acceleration was 60 to 65 m/s^2 at each of the two ends C and D and 140 m/s^2 at the center B. In the second comparative example, the acceleration was 22 to 24 m/s^2 at each of the two ends C and D and 42 m/s^2 at the center B.

Comparing the three cases at the center B, the acceleration measured in the first embodiment is lower by about 94% than that measured in the first comparative example and by about 80% than that measured in the second comparative example. Comparing the three cases at the ends C and D, the acceleration measured in the first embodiment is lower by about 92% than that measured in the first comparative example and by about 77% than that measured in the second comparative example.

The above results show that the effect of vibration damping is enhanced by employing the damping member 118 having free ends. In the second comparative example, the reinforcing member 119 needs to have a large mass and a large size so as to damp the vibration. Consequently, the size of the primary-transfer unit 112 increases. Furthermore, in the second comparative example, the reinforcing member 119 is not deformable and withstands the vibration. Therefore, if a certain stress is applied to the reinforcing member 119 repeatedly, the reinforcing member 119 may suffer from fatigue and may be damaged. In contrast, the damping member 118 according to the first embodiment is bendable by having the two free ends and thus consumes some kinetic energy. Therefore, the occurrence of damage to the damping member 118 after repeated application of a certain stress thereto is suppressed.

Hence, in the first embodiment employing the damping member 118, the primary-transfer unit 112 can have a light and simple configuration while the vibration of the primary-transfer unit 112 is damped.

Furthermore, since the damping member 118 is made of sheet metal and the thicknesswise direction thereof corresponds to the direction of vibration, air resistance that occurs when the damping member 118 vibrates increases the effect of vibration damping. While the first embodiment concerns a case where the damping member 118 is made of sheet metal, the damping member 118 is not limited to be made of sheet metal and may be made of, for example, a plastic plate with weights attached to the free ends of the plate.

Moreover, the damping member 118 may be formed of a plurality of members. For example, the damping member 118 may be divided into two members, with one end of each of the two members that is nearer to the belt-width-direction center of the damping member 118 being fastened to the supporting member 114 and with the other end of each of the two members being a free end.

The damping member 118 is not limited to a member that is fastened only at the belt-width-direction center thereof. For example, FIG. 15 illustrates a modification of the primary-transfer unit 112 according to the first embodiment, in which the damping member 118 is fastened in a different manner. The primary-transfer unit 112 illustrated in FIG. 15

differs from the primary-transfer unit **112** illustrated in FIG. **10** in that the damping member **118** is fastened to the supporting member **114** at two belt-width-direction points thereof with two screws, respectively. Yet, the two belt-width-direction ends of the damping member **118** of the primary-transfer unit **112** illustrated in FIG. **15** are free ends. Therefore, the damping member **118** illustrated in FIG. **15** can also damp the vibration of the primary-transfer unit **112**. Alternatively, referring to FIG. **16**, the damping member **118** may be provided on the downstream side of the supporting member **114** in the direction of belt rotation.

Alternatively, referring to FIG. **17A**, the damping member **118** may be attached to the supporting member **114** with a viscoelastic member **122** such as two-sided adhesive tape, instead of being fastened with a screw or the like. In such a configuration, while the damping member **118** as a whole vibrates with a phase different from that of the vibration of the supporting member **114**, the free ends at the two ends of the damping member **118** each vibrate with a phase yet different from that of the overall vibration of the damping member **118**. Therefore, the vibration of the primary-transfer unit **112** can be damped more effectively. Alternatively, referring to FIG. **17B**, the two ends of the damping member **118** may each be attached to the supporting member **114** with the viscoelastic member **122** such as two-sided adhesive tape. Alternatively, the damping member **118** and the supporting member **114** may be integrated into a single unit. FIG. **18A** illustrates a primary-transfer unit **222** according to another modification of the first embodiment. FIG. **18B** is a sectional view of the primary-transfer unit **222**. The primary-transfer unit **222** includes a damping portion **123B** and a supporting portion **123A** that are integrated into a single unit. If the damping portion **123B** has free ends, the damping portion **123B** produces the same advantageous effect as that produced by the primary-transfer unit **112**.

FIG. **20** illustrates a yet another modification of the primary-transfer unit **112**. The damping member **118** illustrated in FIG. **20** includes folded parts **118a** at two respective ends thereof. Since the damping member **118** includes the folded parts **118a**, the natural frequency of the primary-transfer unit **112** is adjusted by the weight of the folded parts **118a** even if there is not enough space in the belt-width direction.

Second Embodiment

In the first embodiment, the transfer member **113** that is in contact with the inner peripheral surface of the intermediate transfer belt **106** is employed as a rubbing member, and the damping member **118** is fastened to the supporting member **114** that supports the transfer member **113**. In a second embodiment of the present invention, a damping member **133** is fastened to a supporting member **132** that supports a charging brush **131**. The charging brush **131** corresponds to a rubbing member and is provided in contact with the outer peripheral surface of the intermediate transfer belt **106**. The other elements of the second embodiment are the same as those of the first embodiment, and such elements are denoted by corresponding ones of the reference numerals used in the first embodiment.

FIG. **19A** is a schematic diagram of a toner charging unit **130** according to the second embodiment. FIG. **19B** is a schematic top view of the toner charging unit **130**. The toner charging unit **130** includes the charging brush **131** that is in contact with and thus rubs the outer peripheral surface of the intermediate transfer belt **106**, the supporting member **132** that supports the charging brush **131**, and the damping

member **133** that is fastened to the supporting member **132**. When a charging voltage is applied to the charging brush **131**, residual toner particles on the intermediate transfer belt **106** are charged. The supporting member **132** is made of a steel plate and has a rectangular U shape in cross-sectional view. The charging brush **131** is fixedly attached to the bottom surface of the supporting member **132** with two-sided adhesive tape (not illustrated) and is thus supported by the supporting member **132**. The charging brush **131** is a rubbing member that keeps in contact with the intermediate transfer belt **106** in such a manner as to be unrotatable with respect to the supporting member **132**.

The charging brush **131** is provided across the intermediate transfer belt **106** from the secondary-transfer counter roller **101** and is in contact with the outer peripheral surface of the intermediate transfer belt **106** over the entirety in the belt-width direction. The supporting member **132** is fastened to the transfer unit or a body frame (not illustrated) at the two belt-width-direction ends thereof with screws or the like and is thus positioned. As illustrated in FIGS. **19A** and **19B**, the damping member **133**, which is made of a steel plate or the like, is fastened to the belt-width-direction center of a side face of the supporting member **132** with a screw or the like.

As with the case of the first embodiment, the damping member **133** needs to be fastened at a position where the amplitude of vibration of the supporting member **132** in the direction of belt rotation is substantially largest. Hence, in the second embodiment, the damping member **133** is fastened at the above position. Furthermore, the two belt-width-direction ends of the damping member **133** are free ends and are out of contact with any components including the supporting member **132**.

In such a configuration, when the intermediate transfer belt **106** rotates in a direction C, the resultant of the frictional force and the attractive force that occur between the intermediate transfer belt **106** and the charging brush **131** and the restoring force of the supporting member **132** pull each other, whereby the toner charging unit **130** vibrates in the direction C by being repeatedly bent in a bow-like shape. However, the vibration is transmitted to the damping member **133**. Therefore, the two ends of the damping member **133** vibrate in the same direction as the vibration of the supporting member **132** and consume some kinetic energy. Consequently, the amplitude of vibration of the supporting member **132** is suppressed to be small. Thus, the occurrence of damage to any members and the generation of noise due to the vibration are suppressed more than in the related-art apparatus.

While the first and second embodiments each concern an image forming apparatus including the intermediate transfer belt **106** as a transfer belt, the transfer belt is not limited to the intermediate transfer belt **106** and may be a conveying belt that bears and conveys a transfer material.

While the first and second embodiments each concern a case where the transfer belt is an endless rotating member that is rubbed by a rubbing member, the transfer belt may be any other member. For example, a photoconductive belt may be employed as an endless rotating member, and the outer peripheral surface of the photoconductive belt may be provided in contact with and rubbed by a charging brush (a rubbing member) supported by a supporting member to which a damping member is fastened. Employing a damping member having free ends damps the vibration of the rubbing member that rubs the photoconductive belt.

Third Embodiment

In the first embodiment, the transfer member **113** that is in contact with the inner peripheral surface of the interme-

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diate transfer belt **106** is employed as a rubbing member, and the damping member **118** is fastened to the supporting member **114** that supports the transfer member **113**. In a third embodiment of the present invention, a damping member is attached to a supporting member that supports a separating pad serving as a rubbing member that rubs a transfer material that is moved in an image forming operation. Referring to FIG. **21**, an image forming apparatus according to the third embodiment is a typical monochrome laser-beam printer **20**, detailed description of which is omitted herein. In the monochrome laser-beam printer **20**, a transfer material S, such as a sheet, in a sheet cassette is fed to an image forming section by a sheet feeding mechanism **320**. The sheet feeding mechanism **320** is a rubbing unit that includes a rubbing member. In the image forming section, a toner image formed on a photoconductive drum is primarily transferred to the transfer material S, and the toner image on the transfer material S is fixed by a fixing device. The transfer material S having the fixed toner image is then discharged to the outside of the printer **20**.

FIG. **22** is a sectional view of the sheet feeding mechanism **320** according to the third embodiment.

When a feed roller **50** receives a driving force from a drive source (not illustrated), the feed roller **50** rotates while being in contact with the transfer material S. The transfer material S that is in contact with the feed roller **50** is conveyed toward the image forming section by the feed roller **50**. In this process, a subsequent transfer material S (not illustrated) comes into contact with a separating pad **51**, whereby the preceding transfer material S is separated from the subsequent transfer material S and is conveyed while being rubbed by the separating pad **51**. The separating pad **51** is supported by a supporting member **52** and is urged toward the feed roller **50** by a spring **53**. In this case, the separating pad **51** serves as a rubbing member that rubs the transfer material S (a moving member) that is moved, and the separating pad **51** is vibrated by the rubbing of the transfer material S, as with the transfer member **113** of the first embodiment. Consequently, the supporting member **52** that supports the separating pad **51** also vibrates, as with the supporting member **114** of the first embodiment.

Hence, in the third embodiment, a damping member **54** (see FIG. **23**) is fastened to the supporting member **52**, whereby the vibration of the separating pad **51** is damped, as with the case of the first embodiment.

FIG. **23** is a perspective view of the sheet feeding mechanism **320**. The separating pad **51** is provided at a position facing the feed roller **50**, and the separating pad **51** is in contact with the feed roller **50** over the entirety in the belt-width direction that is orthogonal to the direction of conveyance of the transfer material S. The separating pad **51** is supported by the supporting member **52**. The supporting member **52** includes a fastening portion **52a**. The damping member **54** is fastened to the fastening portion **52a**. The two belt-width-direction ends of the damping member **54** are positioned within an area where the feed roller **50** is in contact with the transfer material S.

The damping member **54** is not fixed excluding at the position where the damping member **54** is fastened to the fastening portion **52a**. That is, the damping member **54** has free ends as with the damping member **118** of the first embodiment. Thus, the effect of damping is enhanced. As with the case of the first embodiment, employing the damping member **54** damps the vibration of the separating pad **51** and reduces the weight and the complexity of the sheet feeding mechanism **320**.

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Furthermore, since the damping member **54** is made of sheet metal and its thicknesswise direction corresponds to the direction of vibration, air resistance that occurs when the damping member **54** vibrates enhances the effect of damping. While the third embodiment concerns a case where the damping member **54** is made of sheet metal, the damping member **54** is not limited to be made of sheet metal and may alternatively be made of, for example, a plastic plate with weights attached to the free ends of the plate.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

What is claimed is:

1. An image forming apparatus comprising:
 - an image bearing member configured to bear a toner image;
 - a rotatable transfer belt to which the toner image on the image bearing member is transferred to a transfer material; and
 - a transfer device provided in contact with the transfer belt and configured to transfer the toner image from the image bearing member to the transfer belt, wherein the transfer device includes
 - a rubbing member provided in contact with the transfer belt;
 - a supporting member extending in a width direction orthogonal to a moving direction of the transfer belt and supporting the rubbing member;
 - a pressing member configured to press the supporting member so as to press the rubbing member toward the image bearing member; and
 - a damping member fastened to a portion, extending in the width direction, of the supporting member and configured to suppress an amplitude of the supporting member to be small so as to damp vibration of the transfer device by vibrating with respect to the moving direction of the transfer belt at a position of contact of the image bearing member and the transfer belt.
2. The image forming apparatus according to claim 1, wherein two ends of the damping member in the width direction are free ends.
3. The image forming apparatus according to claim 2, wherein the damping member has a curved shape that is bent at a width-direction center such that the two free ends each being shifted by a predetermined angle with respect to the width-direction center.
4. The image forming apparatus according to claim 2, wherein the damping member includes folded parts at the respective free ends.
5. The image forming apparatus according to claim 1, wherein the rubbing member is in contact with an inner peripheral surface of the transfer belt in such a manner as to be unrotatable with respect to the supporting member.
6. The image forming apparatus according to claim 1, wherein the rubbing member is a brush member that includes
 - a base fabric portion supported by the supporting member; and
 - a plurality of conductive fibers fixed to the base fabric portion.

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- 7. The image forming apparatus according to claim 6, wherein the transfer device includes a power feeding unit configured to apply a transfer voltage to the plurality of conductive fibers, and
wherein the power feeding unit pinches a part of the supporting member and a part of the rubbing member. 5
- 8. The image forming apparatus according to claim 1, wherein the damping member is fastened to the supporting member at a position in the width direction where an amount of bend in the supporting member in the direction of rotation of the transfer belt is largest. 10
- 9. The image forming apparatus according to claim 8, wherein the position where the damping member is fastened to the supporting member is a center of the damping member in the width direction. 15
- 10. The image forming apparatus according to claim 1, wherein the transfer device includes a positioning portion configured to position the rubbing member with respect to the image bearing member in the direction of rotation of the transfer belt, and
wherein the positioning portion is connected to the supporting member. 20
- 11. The image forming apparatus according to claim 1, wherein the pressing member configured to press the rubbing member against the image bearing member with the transfer belt and the supporting member interposed between the rubbing member and the supporting member. 25
- 12. The image forming apparatus according to claim 1, wherein the damping member is made of sheet metal. 30
- 13. The image forming apparatus according to claim 1, wherein the damping member is fastened to the supporting member with a screw. 35
- 14. The image forming apparatus according to claim 1, wherein the damping member is fastened to the supporting member with two-sided adhesive tape. 35
- 15. The image forming apparatus according to claim 1, wherein the damping member is fastened to the supporting member at a position on an upstream side of the supporting member in the direction of rotation of the transfer belt. 40
- 16. The image forming apparatus according to claim 1, wherein the transfer belt is an intermediate transfer belt to which the toner image is primarily transferred from the image bearing member. 45
- 17. The image forming apparatus according to claim 1, wherein the transfer belt is a conveying belt that conveys a transfer material to which the toner image is transferred from the image bearing member. 45
- 18. The image forming apparatus according to claim 1, wherein the damping member is fastened to the supporting member, and an end of the damping member is a free end. 50

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- 19. An image forming apparatus comprising:
a rubbing unit that includes
a rubbing member, provided in contact with a moving member, configured to rub the moving member;
a supporting member supporting the rubbing member;
a pressing member configured to press the supporting member so as to press the rubbing member toward the moving member; and
a damping member having at least one free end, fastened to the supporting member, and configured to suppress an amplitude of the supporting member to be small so as to damp vibration of the rubbing member by vibrating with respect to a moving direction of the moving member.
- 20. The image forming apparatus according to claim 19, wherein the damping member is fastened to the supporting member, and an end of the damping member in a width direction that is orthogonal to a direction of movement of the moving member is a free end.
- 21. The image forming apparatus according to claim 20, wherein two ends of the damping member in the width direction are free ends.
- 22. The image forming apparatus according to claim 21, wherein the damping member has a curved shape that is bent at a width-direction center such that the two free ends each being shifted by a predetermined angle with respect to the width-direction center.
- 23. The image forming apparatus according to claim 20, wherein the damping member includes folded parts at the respective free ends.
- 24. The image forming apparatus according to claim 19, wherein the damping member is made of sheet metal.
- 25. The image forming apparatus according to claim 19, wherein the damping member is fastened to the supporting member with a screw.
- 26. The image forming apparatus according to claim 19, wherein the damping member is fastened to the supporting member with two-sided adhesive tape.
- 27. The image forming apparatus according to claim 19, wherein the rubbing unit includes a separating pad as the rubbing member,
wherein the separating pad faces a feed roller configured to feed a transfer material while being in contact with the transfer material, and
wherein the separating pad rubs the sheet, the transfer material being the moving member.
- 28. The image forming apparatus according to claim 27, wherein the end of the damping member in the width direction are positioned within an area where the feed roller is in contact with the transfer material.

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